The Effect of Earmuff and Earplug Use on Preterm Infants Towards Oxygen Saturation and Pulse

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Abstract

Background: A bright circumstance, cold temperatures with loud noise and many activities around can influence oxygen saturation and pulse in preterm baby.
Purpose: This study aimed to identify the effect of using earmuffs and earplugs on the physiological response of preterm infants.
Methods: This crossover study involved 15 medically stable preterm infants treated in a closed incubator. It used the consecutive sampling technique where the babies' physiological response using Neonatal Pulse Oximetri was observed for 30 seconds every 15 minutes for two hours of using earmuffs and earplugs.
Results: The result of repeated ANOVA analysis showed that there is no significant difference of pulse repetition frequency before, during, and after using the earmuff and earplug to preterm infants. Meanwhile, statistically, there was a difference in the mean of oxygen saturation during and after using the earmuff with p = 0.019.
Conclusion: The use of ear protection (earmuff and earplug) could assist and support premature infants in maintaining physiological condition. Earplugs are considered better than earmuffs for maintaining a preterm infant's physiological condition.

Keywords: earmuffs; earplugs; premature; physiological responses.

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Introduction

Preterm birth is one of the contributors of high neonatal mortality rate in Indonesia, making Indonesia as a country with the 5th leading preterm birth accounted for 675,700 people. While being nurtured, the physical conditions of the treatment room such as the light, the sound, the temperature, the activities nearby, and the room arrangement have a certain impact on the infant's development (Altimier et al., 2015). The NICU room is frequently illustrated as a noisy place due to unexpected noise from the alarm, ventilators, phone, and staff conversation which are truly susceptible to preterm infants (Beal, 2006).

American Academy of Pediatric recommends a noise level of <45 dB in the NICU room, yet the noise level often exceeds this standard. A sudden loud noise has proven to trigger immediate physiological effects such as increased heart rate, blood pressure, respiration and sleep cycle issue, and an increase on the intracranial pressure (ICP) as well as affecting the development of long-term neurodevelopment like language and hearing development (Wachman & Lahav, 2016). Noise contributes to sleep disorders, hearing damage, and decreased oxygen saturation that could have negative impacts on the development of the nervous system (Ranganna & Bustani, 2011). An attempt to reduce noise received by each infant can be accomplished by using earmuffs or earplugs that are designed to adjust the infants' head or using a tool to muffle noises on the incubator cover (Almadhoob & Ohlsson, 2020).

Based on the preliminary research, the noise level of the room ranged

from 55 to 90 dB. While inside the incubator, its level ranged from 58 to 75 dB. The measurement was conducted using the 4-in-1 digital multifunction environment meter. This condition is unquestionably not in line with the American Academy of Pediatric recommendation that limits noises in NICU rooms to around 45 Db. Therefore, most of the preterm infants in the incubator are not protected from the noises around. This study aimed to identify the effect of using earmuffs and earplugs on the physiological response of preterm infants. Earmuffs and earplugs are individual interventions that reduce noise up to 22dB compared to general interventions by modifying the environment which only reduces noise by 6–8 dB.

Methods

Design

This study used a crossover study design where respondents received more than one intervention (Polit, D.F., Beck, 2016). With this research design, the research subjects had control over themselves. This study was carried out from September to November 2017. Each respondent with an odd number initially used earmuffs (treatment A), while each respondent received an even number used earplugs (treatment B). This treatment using earmuffs and earplugs was completed in two hours. There was a break (washout phase) between the first and the second treatment to avoid the effect of the first treatment on the next treatment. The treatment was stopped for 24 hours and hereafter, each respondent received a reverse treatment. Respondents with odd numbers received treatment B whereas treatment A was given to respondents with even numbers. The effect of the treatment was then compared.

Setting and Sample

This study was conducted in the Perinatology rooms of several hospitals in Riau province: Petala Bumi Hospital, Bangkinang Hospital, Selasih Kerinci Hospital, Eria Bunda Mother and Child Hospital, and Mother and Child Hospital of Andini, Pekanbaru. Those hospitals were chosen because the noise intensity at each hospital is not yet consistent with the American Academy of Pediatric recommendation. This is known from noise level measurements carried out by researchers in the perinatology room in each hospital. The population of this study was premature infants who had been undergoing treatment at the neonatal care in 5 hospitals in Riau Province. Inclusion criteria for this research were: infant with gestational age between 28 to less than 37 weeks, infant had been treated in a Neonatal Intensive Care minimum in 2 days, infant did not use any mechanical ventilation and was under a tight control of blood gas analysis, infant was in level 2 that needed a higher level of care and infant was under a closed incubator treatment. Based on the inclusion criteria and preliminary research, the sample size was determined using the paired mean difference formula. 15 Preterm infants were taken as samples using a consecutive sampling technique and none of the samples was dropout.

Instruments

In this study, the researchers used the Anderson Behavioral State Scale (ABSS) with a kappa value of 0.85, which has been used by previous researchers (Syahreni, 2010). To ensure the instrument validity of oxygen saturation and pulse frequency, the researchers used the measuring tools utilized by the hospital in which they had been initially calibrated. Observation sheets A and B were also used. Observation sheet A encompassed data of respondents' characteristics including gender, gestational age, and chronological age. Whereas observation sheet B covered data on physiological function such as oxygen saturation and pulse frequency based on the measurement time. The tools utilized in the study were 1) Earmuffs from Em's 4 Bub that is designed to protect babies from noises. It was equipped with a headband to fit babies' head. 2) The earplugs used was child-sized soft moldable

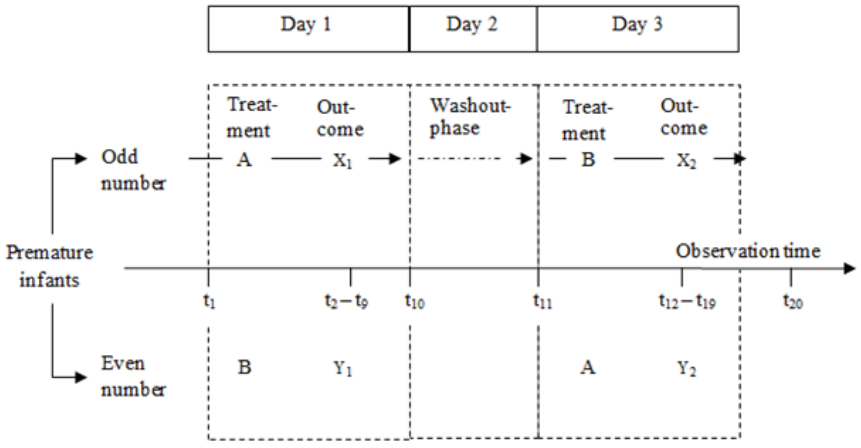

Figure 1. Cross-Over Design

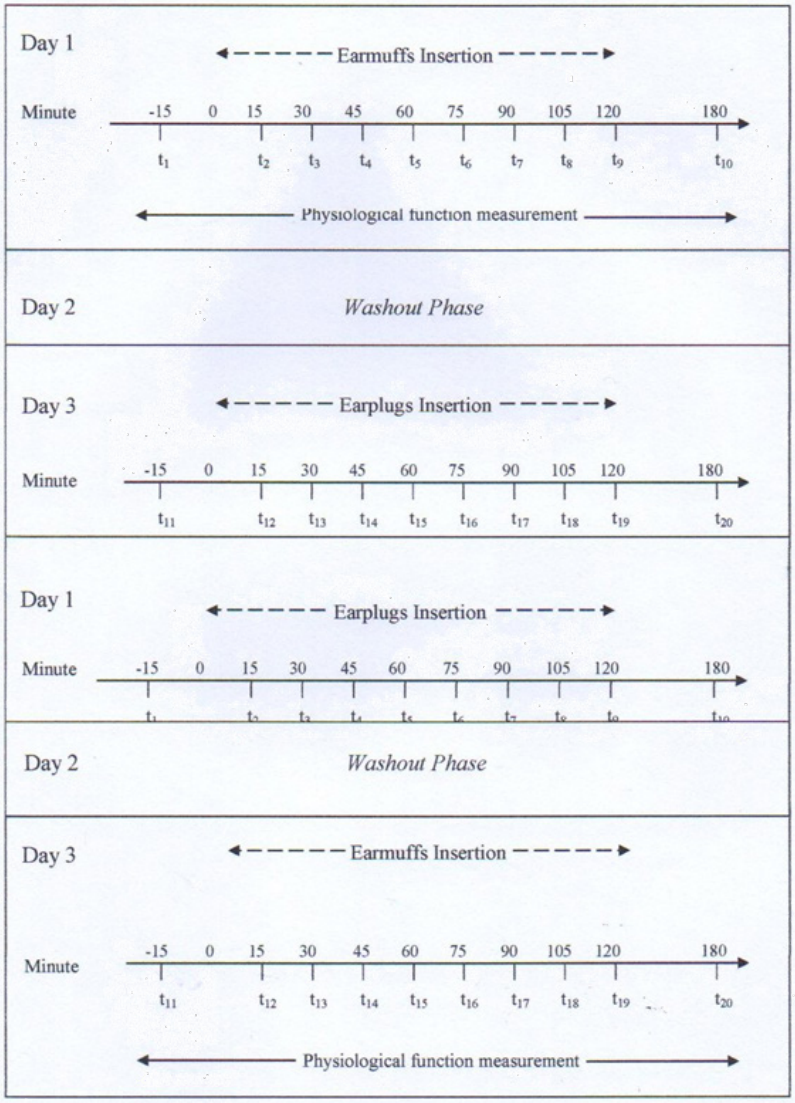

Figure 2. The Measurement on Physiological Function of Respondents with Even Number

silicone from Mack's Earplugs produced by McKeon Products, Inc. USA which has complied with the Environmental Protection Agency (EPA) standard with ANSI S.319 as hearing protection equipment. 3) Neonatal pulse oximeter used in the nursery 4) The 4 in 1 digital multi-function Environment Meter to measure noise level of a room. This tool is designed by combining the function of a sound level meter, light meter, humidity meter and thermometer.

Data Collection and Procedure

The following is the data collection process: 1) First, the infants were given an odd and even number. On the first day, babies with odd number used earmuffs while the ones with even number used earplugs. 2) Second, the physiological function was measured by recording the result of measurement of the oxygen saturation and pulse frequency from the monitoring screen on at (t1), which was 15 minutes before inserting the earmuffs, every 15 minutes for 2 hours of wearing earmuffs (t2-t¬9), and after 60 minutes, the earmuffs were removed (t10). 3) The second day was the washout period when the infants did not wear any earmuff or earplug. 4) On the third day, infants with odd number wore earplugs while the ones received even number wore earmuffs. 5) Physiological function measurement was accomplished on the third day. The oxygen saturation and pulse frequency were recorded from the monitoring screen at (t11); that was 15 minutes before inserting the earmuffs, every 15 minutes for 2 hours of wearing earmuffs (t12-t¬19), and after 60 minutes, the earmuffs were removed (t20).

Data Analysis

Univariate analysis was conducted to understand the frequency distribution as well as to check the percentage and proportion of each variable. The characteristics of variables analyzed in this study include gender, gestational age, chronological age, oxygen saturation, and pulse frequency. Gender was explicated by using frequency distribution and percentage which are considered as categorical data. Meanwhile, numerical variables such as

Table 1. Respondent Distribution Based on Their Characteristics, Oxygen Saturation, and Pulse Frequency (n=15)

Variable	Mean ± SD	Median (min-max)	95% CI
Gestational age	32.33 ± 2.38	32 (28–36)	31.02–33.65
Chronological age	7.22 ± 5.60	6 (2–25)	4.16–10.36
Oxygen saturation Earmuffs			
Before	96.67 ± 1.50	97(94–99)	95.83–97.49
During	96.53 ± 2.64	97(90–100)	95.07–97.99
After	96.00 ± 2.33	96 (92–99)	94.71–97.29
Oxygen saturation Earplugs			
Before	96.67 ± 2.64	98 (91–100)	95.20–98.12
During	97.09 ± 1.67	97.5 (93–99)	96.16–98.01
After	95.80 ± 2.81	96 (90–100)	94.24–97.35
Pulse frequency Earmuffs			
Before	141.13 ± 19.56	135 (100–167)	130.30–151.96
During	140.45 ± 14.67	139.75 (121.13–161)	132.32–148.57
After	139.2 ± 15.03	135 (115–174)	130.87–147.52
Pulse frequency Earplugs			
Before	147.53 ± 16.94	146 (130–186)	138.15–156.91
During	142.38 ± 16.25	147.38 (112–162)	133.38–151.38
After	146.60 ± 17.45	147 (117–172)	136.93–156.26

Table 2. Respondent Distribution Based on Gender (n=15)

Variable	Frequency	Percentage (%)
Gender		
Male	8	53.3
Female	7	46.7

Table 3. The Comparison of the Mean of Oxygen Saturation Before, During, and After Using the Earmuffs and Earplugs (n=15)

Oxygen Saturation of Preterm Infants		Mean ± SD	95% CI	p value
Earmuffs	Before	96.67 ± 1.496	95.838-97.495	0.506
	during	96.53 ± 2.642	95.070-97.997	
	after	96.00 ± 2.329	94.710-97.290	
Earplugs	before	96.67 ± 2.636	95.206-98.127	0.017
	during	97.09 ± 1.674	96.165-98.019	
	after	95.80 ± 2.808	94.245-97.355	

Note: Repeated Anova Test

gestational age, chronological age, oxygen saturation, and pulse frequency were analyzed using the mean, median, standard deviation (SD), as well as the minimum and maximum value at the 95% significance level (α = 0.05). The statistical test in the bivariate analysis is determined based on the assumptions that must be met for each statistical test using repeated measures ANOVA and Pairwise comparison test. All variables were tested for their normality by using the Shapiro Wilk test.

Ethical Consideration

The study was approved by the Health Research Ethics Committee, Faculty of Nursing Indonesia University, Jakarta, Indonesia (approval no.191/UN2.F12.D/HKP.02.04/2017) and written informed consent was obtained from each participant before data collection was conducted.

Results

Respondent characteristics analyzed in this study were described based on the type of data, numerical

Table 4. The Comparison of the Mean of Oxygen Saturation Before, During, and After Using Earmuffs (n=15)

Oxygen Saturation of Preterm Infants		Mean Difference (95%CI)	p value
Earmuffs	Before vs during	0.133(-1.603-1.870)	1.000
	Before vs after	0.667(-0.983-2.316)	0.871
	During vs after	0.5339(-0.964-2.031)	1.000
Earplugs	Before vs during	-0.425(-1.846-0.996)	1.000
	Before vs after	0.867(-1.080-2.813)	0.739
	During vs after	1.292(0.193-2.391)	0.019

Note: Pairwise Comparison Test

Table 5. The Comparison of the Mean of Pulse Frequency Before, During, and After Using the Earmuffs and Earplugs (n=15)

Pulse Frequency of Preterm Infants		Mean	SD	95% CI	p value
Earmuffs	Before	141.133	19.555	130.304-151.963	0.893
	during	140.450	14.668	132.327-148.573	
	after	139.200	15.029	130.877-147.523	
Earplugs	before	147.53	(16.9)	138.154-156.912	0.116
	during	142.38	(16.2)	133.386-151.381	
	after	146.60	(17.4)	136.938-156.262	

Note: Repeated Anova Test

and categorical data. Numerical variables consisting of gestational age, chronological age, oxygen saturation, and pulse frequency were analyzed using the mean, median, standard deviation (SD), as well as the minimum and maximum value at the 95% significance level (α = 0.05).

The number of male premature infants was almost the same as the females as illustrated in the following table.

The result of bivariate analysis on the comparison of the mean of oxygen saturation before, during, and after using the earmuffs and earplugs using repeated ANOVA test shows that the highest mean of oxygen saturation of premature infants using earmuffs was before the earmuffs used. The second highest mean was obtained during the use of earmuffs and lastly after its use. Further, the statistical test result done to compare oxygen saturation before, during, and after using the earmuffs designates that H0 was rejected. This implies that there was no significant difference in the oxygen saturation of premature infants before, during, and after using the earmuffs (p=0.506). Moreover, the highest mean of oxygen saturation on premature infants with earplugs was gained while using the earplugs. The second highest mean was before using earplugs and the lowest was after using earplugs. The results can be seen in Table 3 below.

The result of the pairwise comparison test to compare the mean of oxygen saturation before, during, and after using the earplugs indicates that the mean of oxygen saturation statistically had at least two different means (p=0.017). The significance value of the comparison for the second and the third measurement was < 0.05 (p=0.019). There was a different mean of oxygen saturation during and after using the earplugs. Further detailed result can be seen in Table 4 below.

The highest mean of pulse frequency on premature infants with earmuffs was gained before the earmuffs were used. The second highest mean was obtained during the use of earmuffs. After its use, the mean was lower. The result of the statistical test used to compare the mean of pulse frequency before, during, and after using the earmuffs shows no significant difference (p=0.893). Meanwhile, the mean of pulse frequency of preterm infants from the highest to the lowest was obtained consecutively before, after, and during the use of earplugs. The statistical test employed to contrast the mean of pulse frequency before, during, and after using the earplugs also results in no substantial difference with p=0.116. The result is further explicated in the following table below.

Discussion

Respondents in this study were premature infants who were nursed at several hospitals in Pekanbaru and its neighborhood such as Petala Bumi Hospital, Bangkinang Hospital, Selasih Kerinci Hospital, Eria Bunda Mother and Child Hospital, and Mother and Child Hospital of Andini, Pekanbaru. The samples in this study were infants who were born fewer than 37 weeks with an average gestational age of 32.33 weeks. Premature infants were born with organ immaturity so that the environment as well as the use of medical tools in the hospital room are excessive stimulus and can cause prolonged stress on the preterm infants (Tilly Reid, 2001). The noise intensity of the treatment rooms for infants

in this study was high with an average noise level of 56,31 dB. According to Hassanein et al. (2013), cardio-respiratory equipment alarms could increase noise intensity to 73 dB, endotracheal suctioning to 68 dB, and the sound of telephone ringing to 83 dB. Reducing the noise received by infants is one of the ways that can be done to diminish sensory stimulation (Pineda, 2015).

Premature infants born before 28 weeks' gestation also have an immature auditory system. Premature infants are unable to coordinate autonomic response towards the environment and tactile stimulation until 32–34 weeks of gestation. They need more energy to optimize the immature organs. The infants do not have a strong ability to adapt, thus assistance and support by using earmuffs or earplugs could help reduce noise intensity received by the baby. Nurses play a role in diminishing noise intensity and create a healing environment which allows the infants to maintain energy for their growth and development.

The mean chronological age of respondents in this study was 7.26 days. The increase in the chronological age of premature infants is expected to enable them to respond to any stimuli received from the surroundings just as what occurs in the neonatal care. In this study, the preterm infants were at least 2 days old to be able to be involved in the study with an estimate that they had passed the transition period and had received minimum treatment or medical intervention as the first attempt to save life.

Gender is not a factor that influences premature infants. The research result shows that there were almost similar numbers of male and female infants. This is in accordance with a study conducted by Joshi & Tada, (2017) revealing that there is no significant effect of gender to pulse frequency, respiratory rate, or oxygen saturation.

The average of oxygen saturation of premature infants in this research proves no significant difference before, during, and after using the earmuffs. It is consistent with a study by Duran et al. (2012) reporting no significant difference of oxygen saturation to 20 babies using earmuffs involved in the study with p=0,55. The measurement was carried out during babies' rest where they did not receive any treatment that could disturb the babies. That measurement agrees with Abdeyazdan et al., study (2014) disclosing a decrease on oxygen saturation that occurred to the control group (without earmuffs) was due to an increase on activities in the room such as medical visits (e.g. doctor check-ups and routine treatment given to babies) which eventually cause a higher noise level. This is where nurses have an important role to provide earplugs to premature babies so that they are not disturbed by environmental activities around them.

The use of earplugs, on the other hand, shows significant differences during and after its use. An increase in oxygen saturation during the use of earplugs indicates that the earplugs do not interfere with the position of the premature infants. The use of earplugs consistent with the infants' age will not interfere the treatment routine nor cause any obstacle, resuscitation process, and not injure the infants (Eman A, 2017). In addition, adjusting sleeping position both in supine or quarter prone position affords comfort and increases the infants oxygen saturation (Utario, 2017).

The result of this study also designates that there is no significant difference of the mean of pulse frequency before, during or after using the earplugs or earmuffs. The mean of pulse frequency is 140.45 for earmuffs and 142.3 for earplugs. Grounded on the researchers' observation, the premature infants' pulse frequency is not too fluctuated as the study is conducted when the infants are taking a rest. This suggests that during the study, the infants do not receive any intervention, especially the ones that could stimulate pain disrupting physiological stability. The strength of this research is that the equipment used complies with the Environmental Protection Agency (EPA) standard, which has ANSI S.319 as hearing protection equipment. These earmuffs and earplugs can reduce sound entering the ear (Noise Reduction Rating – NRR) by 22 decibels. However, the limitation of this study lies in the difficulty of finding samples that match the established criteria. Nurses are expected to put earplugs on premature babies as an intervention to overcome the noise of the care environment.

Conclusion

The use of earplugs on preterm infants could significantly improve oxygen saturation. It explicates that the earplugs do not interfere with the infants' position. Additionally, the use of earplugs on preterm infants is better compared to earmuffs. The use of earplugs consistent with the infants' age will not interfere the treatment routine nor cause any obstacle, resuscitation, and not injure the infants. However, there is no significant difference in the mean of pulse frequency before, during or after using the earplugs or earmuffs.

Declaration of Conflicting Interests

The authors declare no conflict of interest in this study.

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Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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